

Modernized Biomass Energy in China: Jilin

Project Overview

Dr. Pat DeLaquil
Chief Technical Advisor

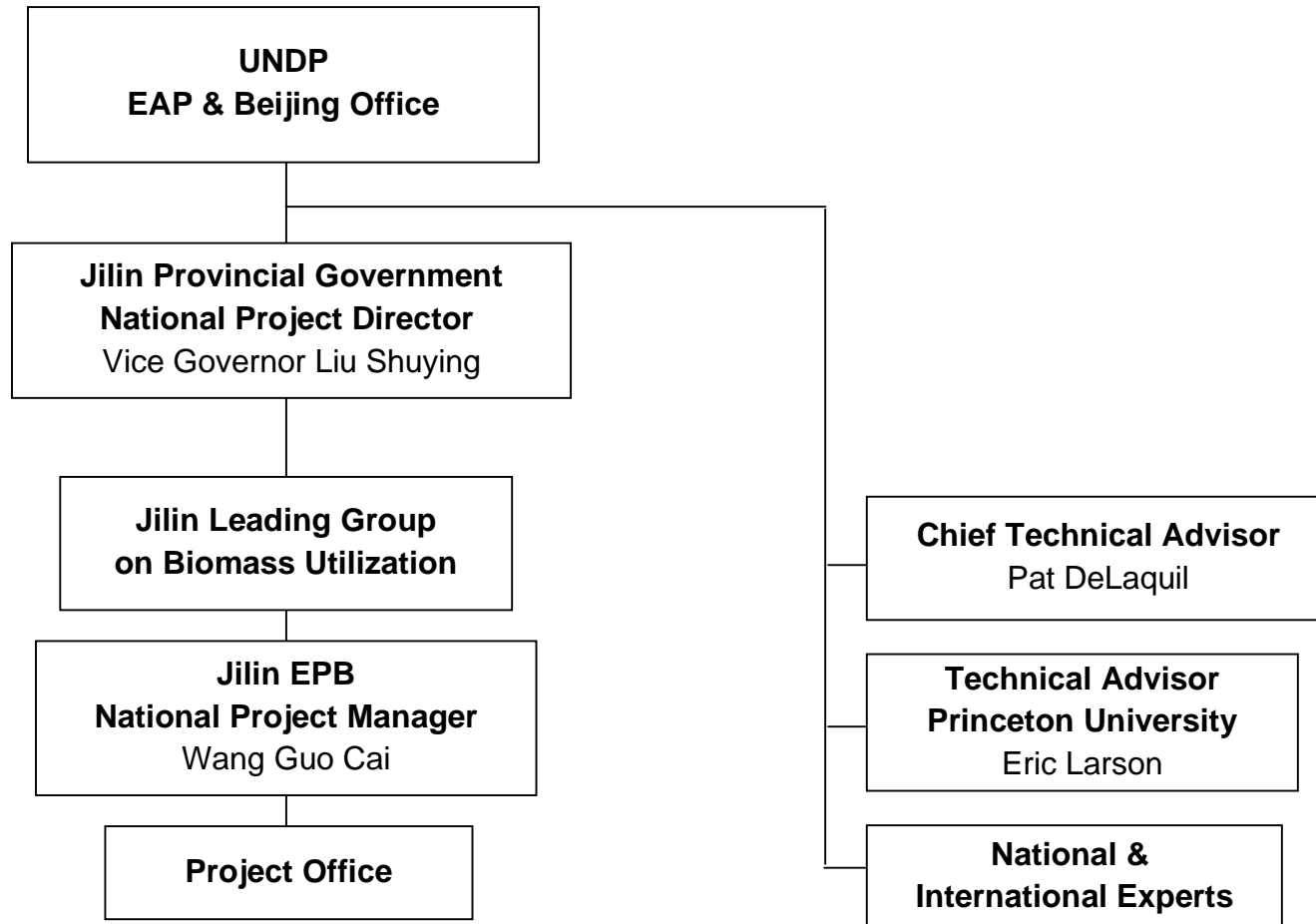
Contents

- 1. Background and Organization**
- 2. Goal & Objectives**
- 3. Biomass Gasification**
- 4. Combined Heat & Power**
- 5. Preliminary Economics**

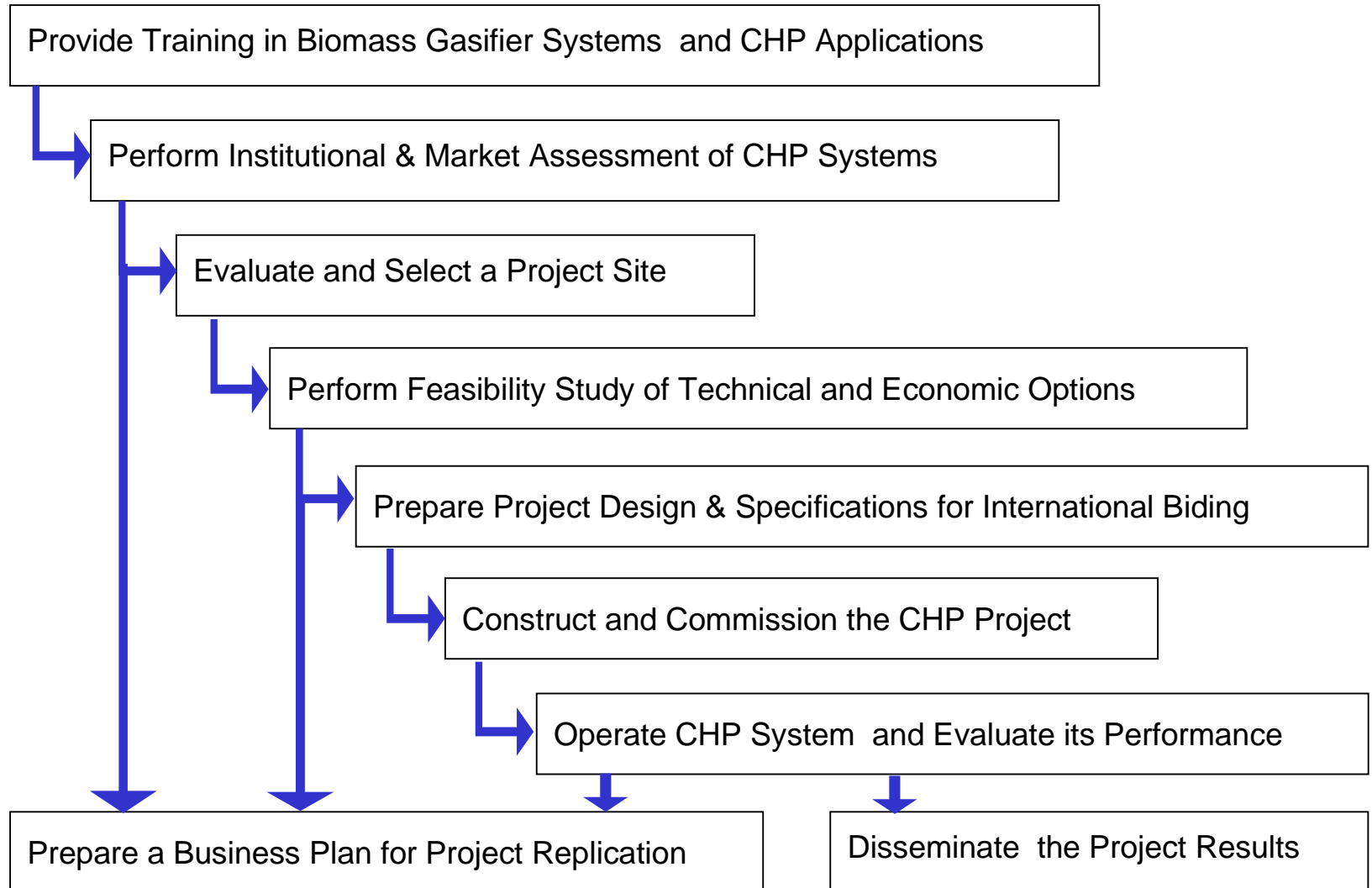
1. Background and Organization

- ❁ **Project identified by China Council for International Cooperation on Environment and Development**
- ❁ **Project promoted by Robert Williams at Princeton University Center for Energy and Environmental Studies**
- ❁ **Project co-funded by UNDP (with funds from the UN Foundation) and the Jilin Provincial Government**

Organization Chart



Project Approach



2. Project Goal & Objectives

Long-term Goal:

Promote widespread use of gasified biomass for for combined heat and power (CHP) generation in China and other developing countries

Project Objectives

- ❁ **Improve local environmental conditions by reducing indoor air pollution**
- ❁ **Enhance living standards and increase options for education, recreation and income generation through improved heating, cooking and illumination services**
- ❁ **Establish a local market for recovery and utilization of agricultural residues**
- ❁ **Demonstrate a distributed means of electricity generation based on a renewable resource**
- ❁ **Familiarize Chinese experts and officials with the technical, economic and organizational aspects of CHP**
- ❁ **Identify policies and regulations to remove or mitigate economic and institutional barriers to project replication**

Improve Local Environmental Conditions

- ✿ High indoor air pollution from traditional heating & cooking
- ✿ Respiratory disease is leading cause of death in China
- ✿ Field burning of excess residues causes severe outdoor air pollution
- ✿ Coal briquettes do not reduce indoor pollution and increase the problem of excess residues
- ✿ Residue quantities are sufficient for cooking, heating and electricity needs

Enhance Living Standards and Clean Development Options

- ✿ Project converts residue wastes into a valuable commodity and generates revenue to pay villagers for collecting and delivering residues
- ✿ Improved heating and cooking methods free time for education, income generation and recreation

Demonstrate Distributed Generation Based on a Renewable Resource

- ❁ Distributed electricity generation provides important benefits to the utility
 - ❁ Greater line utilization
 - ❁ Reduced transformer and other equipment upgrades
 - ❁ Improved voltage stability
- ❁ Use of renewable resources displaces coal from conventional power plants
- ❁ Revenue from electricity sales to the grid is critical to the project economics

Familiarize Chinese Experts and Officials With CH P Technology

- ✿ Multiple training workshops
 - ✿ Technical aspects gasification and CHP
 - ✿ Institutional issues of regulation, taxation and consumer awareness
 - ✿ Site selection, system design, operation and maintenance
 - ✿ Rural energy service company management and administration
- ✿ Market assessment & business plan development
- ✿ Dissemination of project results inside and outside China

Identify Policies and Regulations to Support Project Replication

❁ Village & Township Enterprise System

- ❁ Encourages local entrepreneurs

❁ Renewable Portfolio Standard

- ❁ Requires utility to supply a minimum amount of energy from renewable sources
- ❁ Supports utility purchase of surplus electricity from Village Biomass Energy Projects

❁ Rural Energy Concessions

- ❁ Allows local entrepreneurs to provide services that utilities can not

Benefits to China

✿ Use of half the 376 million tons of residues generated per year can:

- ✿ Provide clean cooking gas for 230 million people (27% of rural population)
- ✿ Generate 270 TWh of electricity (30% of all coal generation in 1997)
- ✿ Supply rural heating needs in colder regions

✿ Being a model for other developing countries will:

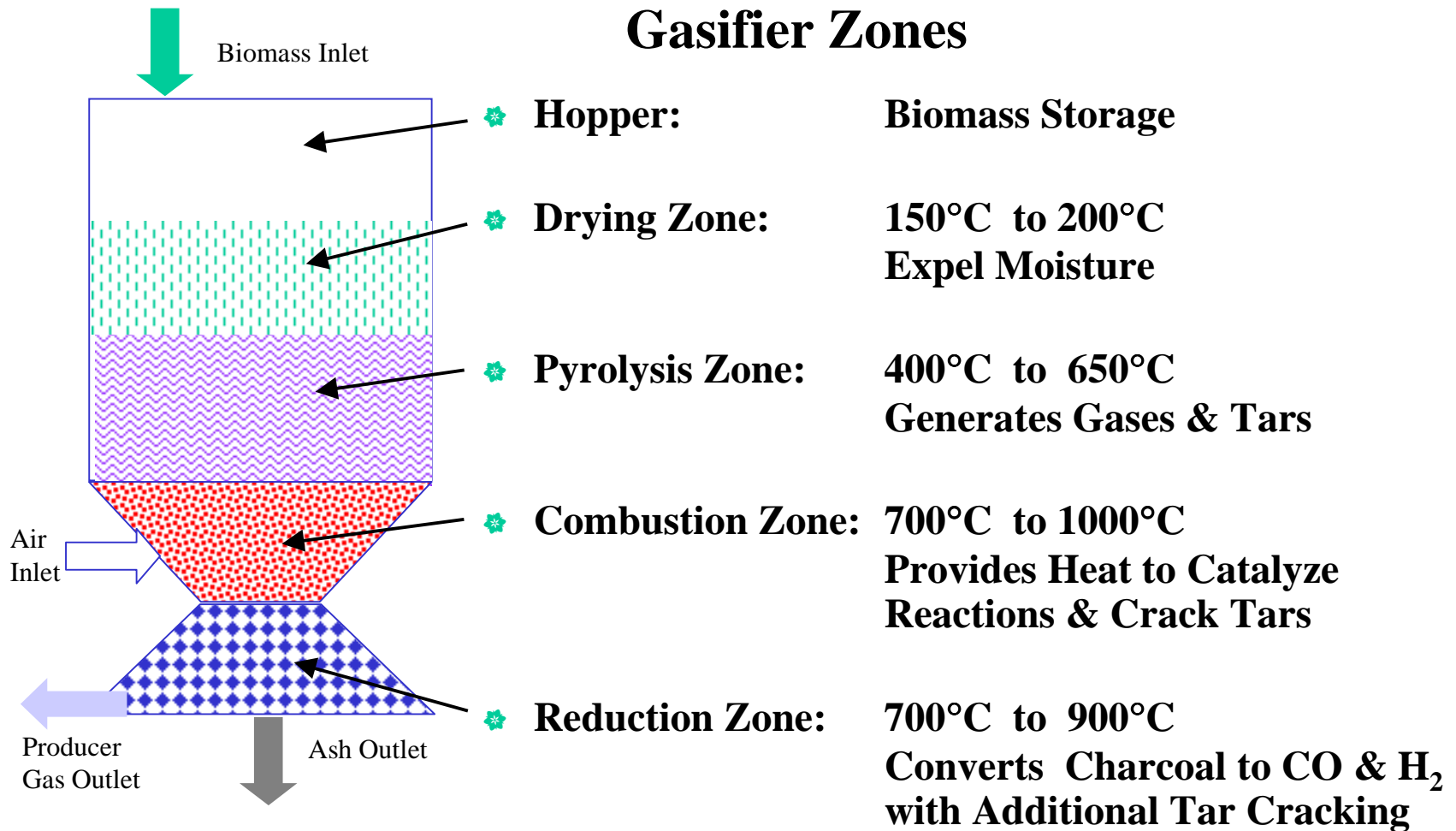
- ✿ Provide significant opportunities for exporting equipment and expertise
- ✿ Increase Chinese influence in the developing world

3. Biomass Gasification

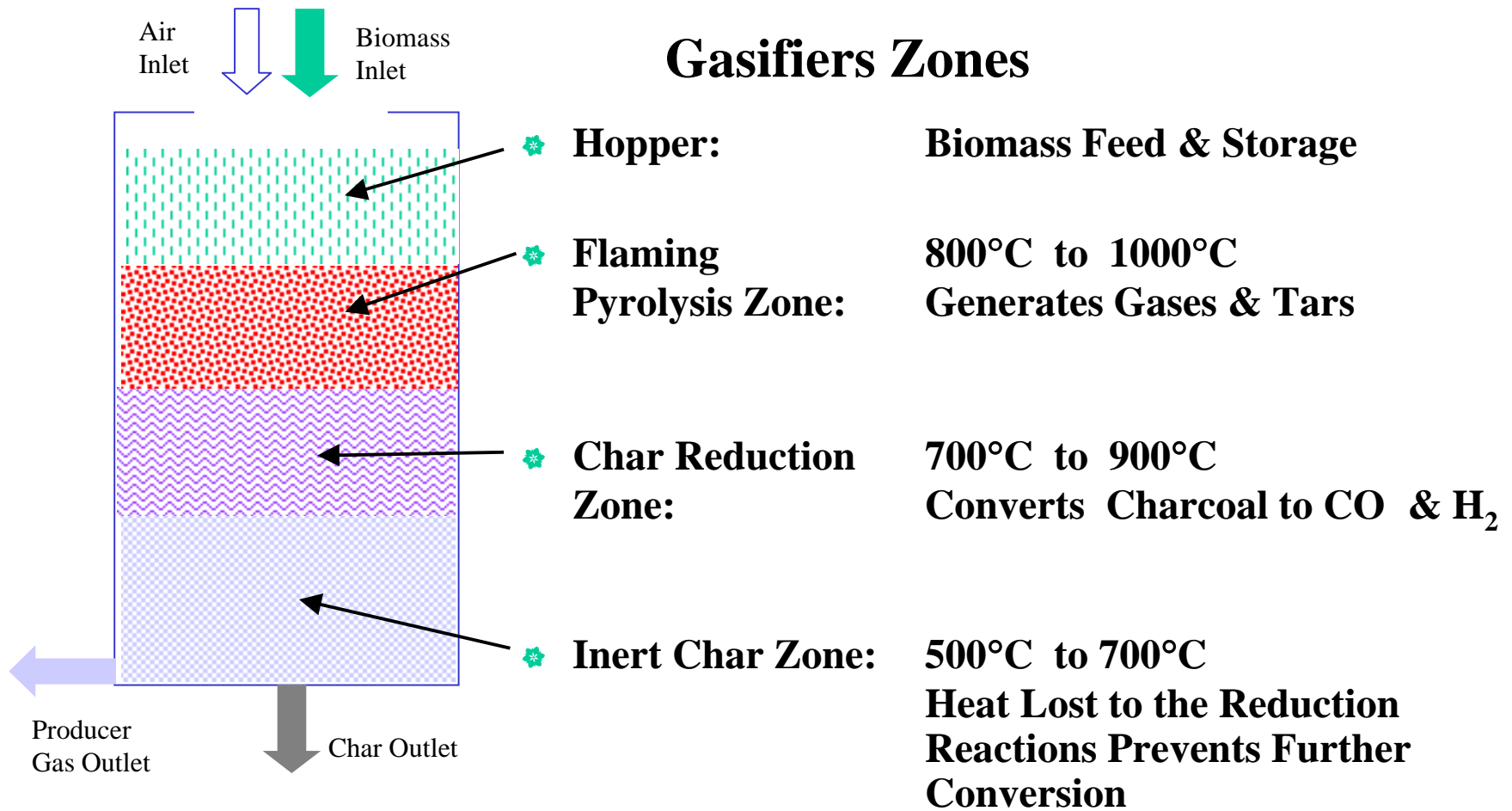
Gasification is One of Three Types of Thermal Processes:

- ✿ **Combustion:** Biomass + Unlimited O₂
=> Heat + CO₂ + H₂O + Ash
- ✿ **Pyrolysis:** Biomass + Heat (No O₂)
=> Charcoal + Oils + Tars + Gases
- ✿ **Gasification:** Biomass + Limited O₂
=> Hot Producer Gas (H₂, CO, CH₄, CO₂, N₂)
Volatile Tars + Ash

Closed-Top Gasifiers Use High-Density Biomass & Produce Low-Tar Gas



Open-Top Gasifiers Use Low-Density Biomass, but Produce Higher-Tar Gas



Producer Gas Characteristics

✿ Typical Composition

✿ 20%-CO, 15%-H₂, 10%-CO₂, 2%-CH₄, 53%-N₂

✿ Energy Content

✿ 5000 KJ/Nm³

✿ Contaminants

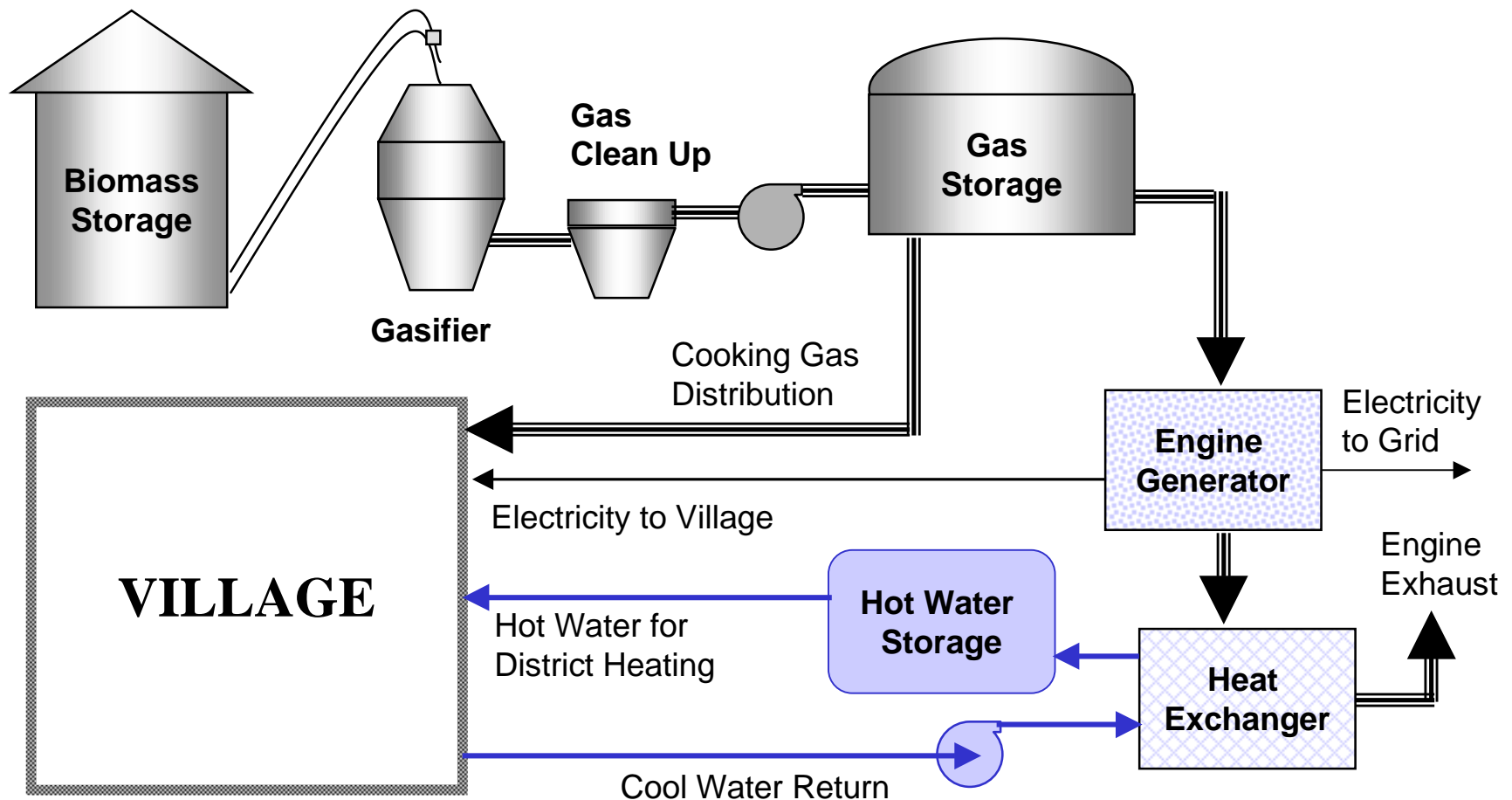
✿ Particulates, tars, water vapor, alkalis

✿ Safety Issues

✿ CO toxicity

✿ Phenols from gas clean-up

4. Biomass Gasification CHP System



Preliminary Criteria for Biomass Gasification System





- ❁ **Must be proven on low-density agricultural residues**
- ❁ **Must generates low-tar “producer” gas or have effective gas cleaning**
- ❁ **Must have commercial systems in operation generating electricity**
- ❁ **Must have safety features to ensure worker protection**
- ❁ **Preferably consist of modular equipment for easy installation, operation and maintenance**

Gas Cleanup Options




Cyclones

-  Remove particulates > 10 microns

Dry Filters

-  Hot gas filters are too expensive for small systems
-  Cold filters require a heat exchanger to cool the gas
-  Remove particulates, but are clogged by tars & moisture
-  Require on-line cleaning mechanisms

Water Scrubbers

-  Effective at removing particulates as small as 1-2 microns
-  Cool gas and remove some tars and alkalis
-  Require scrubber water containment & treatment

Gas Storage Options




- ✿ **Floating Steel Vessel**
- ✿ **Expandable Plastic Vessel**

Primary Criteria are

- ✿ **Cost and**
- ✿ **Worker Safety**

Electricity Generation Options

Dual Fuel Diesel Gensets

-  Reasonably good experience base
-  Insignificant engine derating (10 to 20%)
-  Diesel fuel cost is significant

Spark Engines

-  Smaller experience base
-  Significant engine derating (40 to 60%)
-  No liquid fuel cost

Stirling Engines

-  Close to being commercially available
-  No derating or liquid fuel requirement

Microturbines




-  Under development for producer gas
-  No derating or liquid fuel requirement

District Heat Options

Central Hot Water System

-  Utilizes waste heat from the engine
-  Maximizes electric output from the system
-  Requires significant capital investment

Producer Gas Supply


-  Household hot water heat
-  Household hot air furnace
-  Heater for existing kangas

Basic System Design Issues

Village Energy Requirements

-  Cooking
-  Electricity
-  Heating

Daily & Seasonal Load Distributions

-  Gasifier size
-  Gas storage requirement
-  Heating storage requirement

Genset Size & Capacity Utilization

-  Village requirement
-  Surplus sales to grid

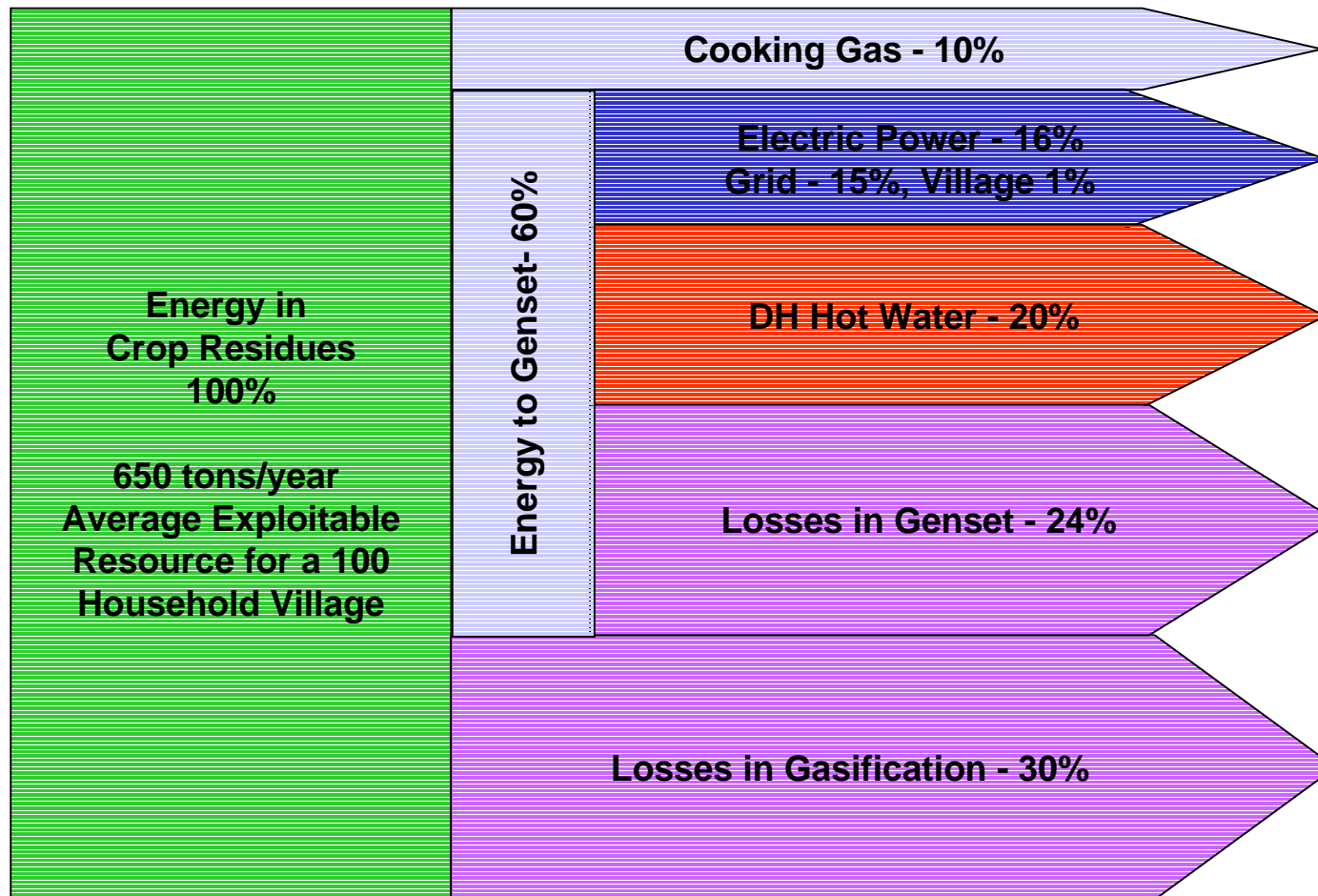
Modeling Required to Optimize System Design

5. Preliminary System Economics*

- ❁ Preliminary economics run for 100 household village using the district hot water heat option
- ❁ Cooking gas is priced slightly below LPG price (\$6/GJ)
- ❁ Heat is priced below the cost of cooking gas (\$5/GJ)
- ❁ Corn stalk is purchased at \$6/tonne
- ❁ Electricity is sold to grid at 5¢/kWh
- ❁ Villagers continue to purchase electricity from grid
- ❁ The plant employs three workers per shift
- ❁ Return on investment is attractive (10 to 14%)

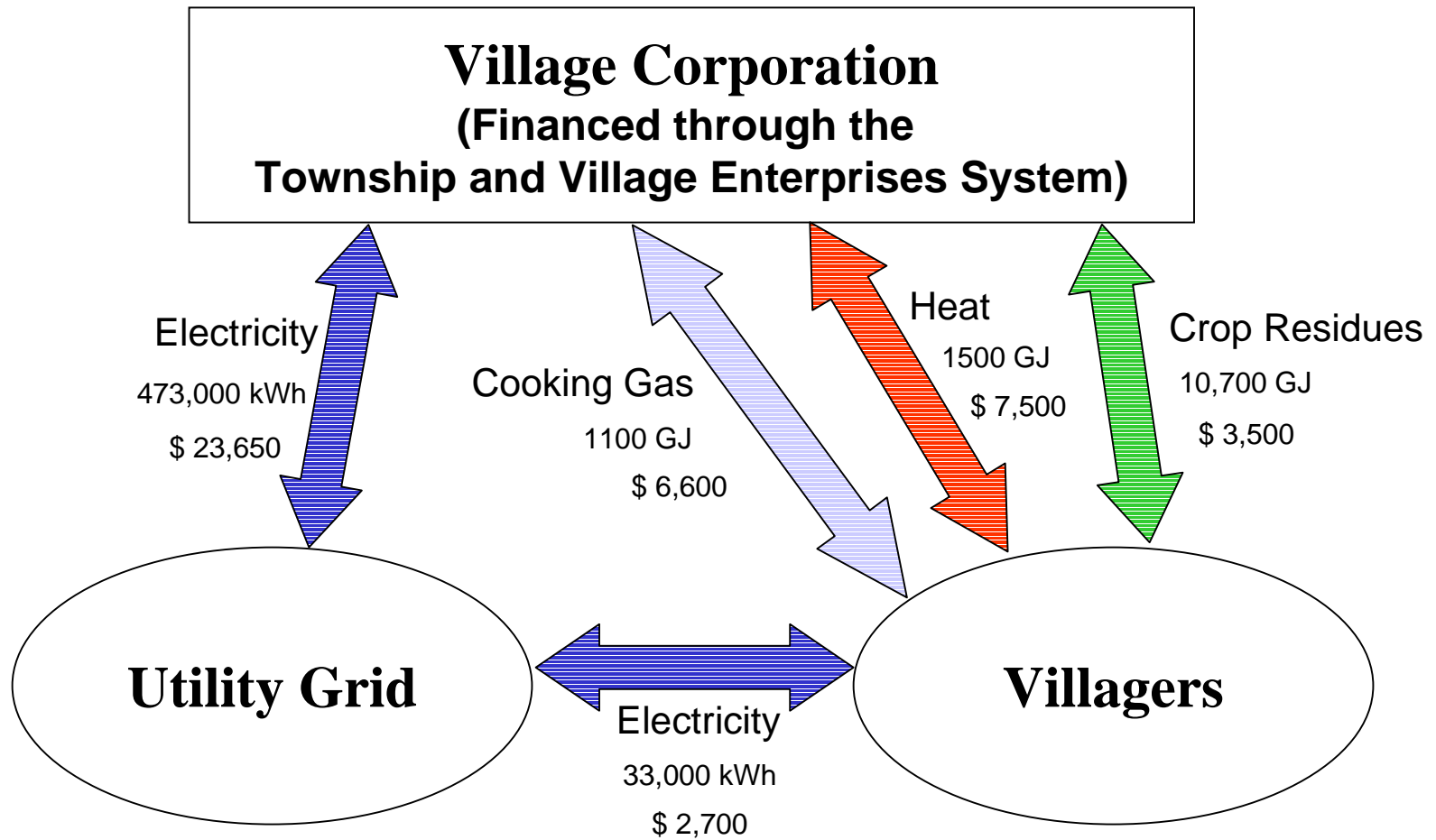
* An Assessment of Biomass-Powered Microturbines and the Potential for Application in Rural China, Paul M. Henderick, PU/CEES Report No. 322, January 2000.

Preliminary Energy Flows for a 100 Household Village



A 100 Household Village Example

Annual Energy and Revenue Flows



CHP System Benefits

